Soil C and N stocks in the sylvopastoral zone of Senegal is influenced by trees

A.J.A. N'GORAN [1,2,3], A.A. DIOUF [2], S. DIATTA [3], A. DJAGOUN [1,3], L. COURNAC [4], L. CHAPUIS-LARDY [4], M.H. ASSOUMA [5], V. BLANFORT [5], S. TAUGOURDEAU [1,5]

1 CIRAD-UMR SELMET PPZS, 2 CSE, 3 UCAD FST, 4 IRD-UMR Eco&Sols & LMI IESOL 5 UMR SELMET-CIRAD -INRA -Sup Agro-Univ Montpellier

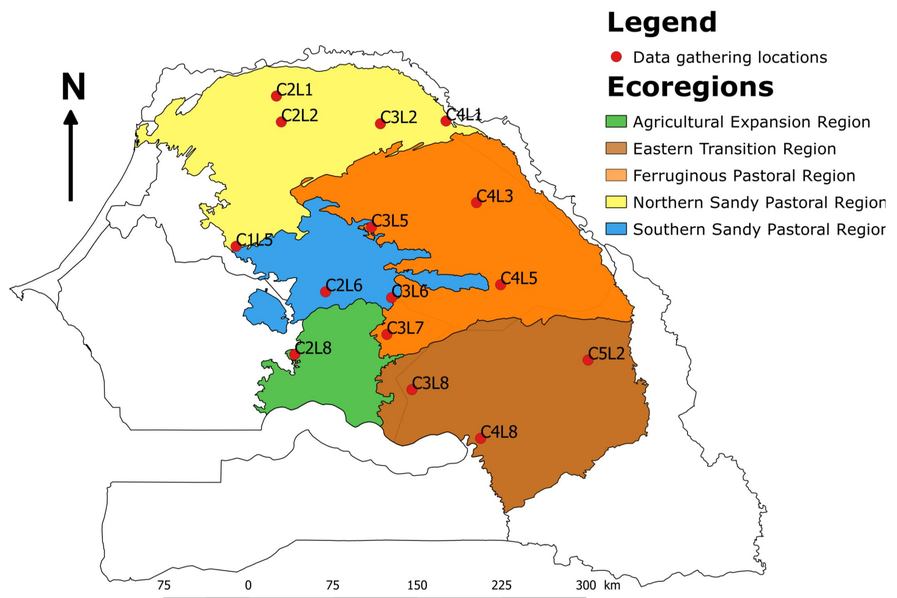
jokebedngoran@gmail.com

1- Context

Pastoral livestock systems in Sahel are criticized for their high intensity of GHG emissions and their negative impact on soil and vegetation. A good management of soil and plants can mitigate this negative environmental impact and increase the contents and stocks of organic carbon in soils.

This study aims to:

- Explore the influence of trees on carbon and nitrogen content in the topsoil.
- Identify the environmental drivers of the soil carbon stocks : biomass, rainfalls, tree cover rate.

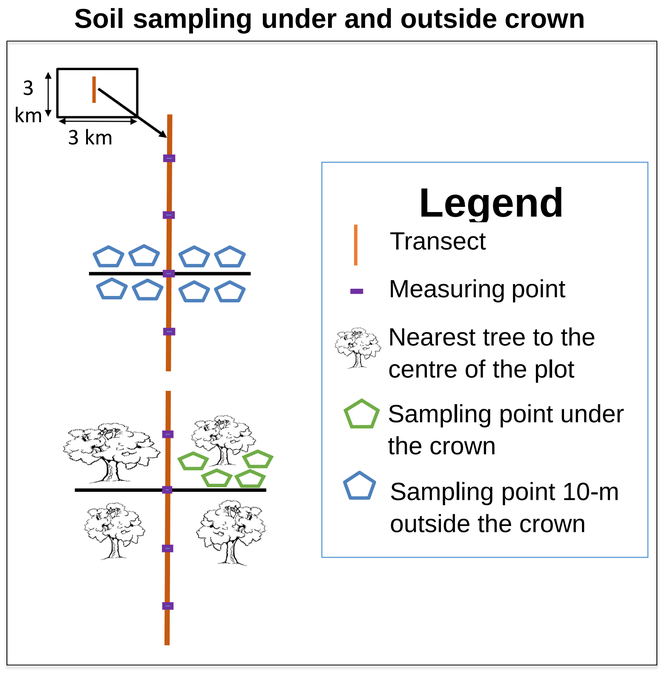


Location of the studied ecoregions in Senegal (Source : CSE ; Tappan G., Sall M, Wood E. and Cushing M 2004. Ecoregions and land cover trends in Senegal. Journal of Arid Environments 59, 427–462)

2- Materials and methods

- Soil sampling outside and under tree crowns (0-10 and 10-30 cm depth) at 15 of the survey control sites monitored by the CSE.
- Prediction of soil carbon and nitrogen contents using the Near Infra-Red Spectroscopy (NIRS)
- Use of the core method to determinate soil bulk density and thus calculate Carbon and Nitrogen stocks

Soil sampling under and outside crown



soil bulk density

NIRS processing for soil C & N prediction

Calculation of Carbon and Nitrogen stocks

$$Stock(site) = Tx \times stock_{SH} + (1 - Tx) \times stock_{HH}$$

Where T_x = woody cover rate; $stock_{SH}$ = stock under crown and $stock_{HH}$ = stock outside crown

3- Results and discussion

- Average carbon stocks in the upper 0-30 cm soil layers varied from 9.3 to 29.7 / 18.5 t.ha^{-1}.
- Soil carbon and nitrogen contents were higher under the tree crowns, and at 0-10 cm deep.
- The soil C-to-N ratio was significantly higher under tree crowns than outside.
- Stocks of soil C increased along a North-South gradient as influenced by rainfall and tree biomass.

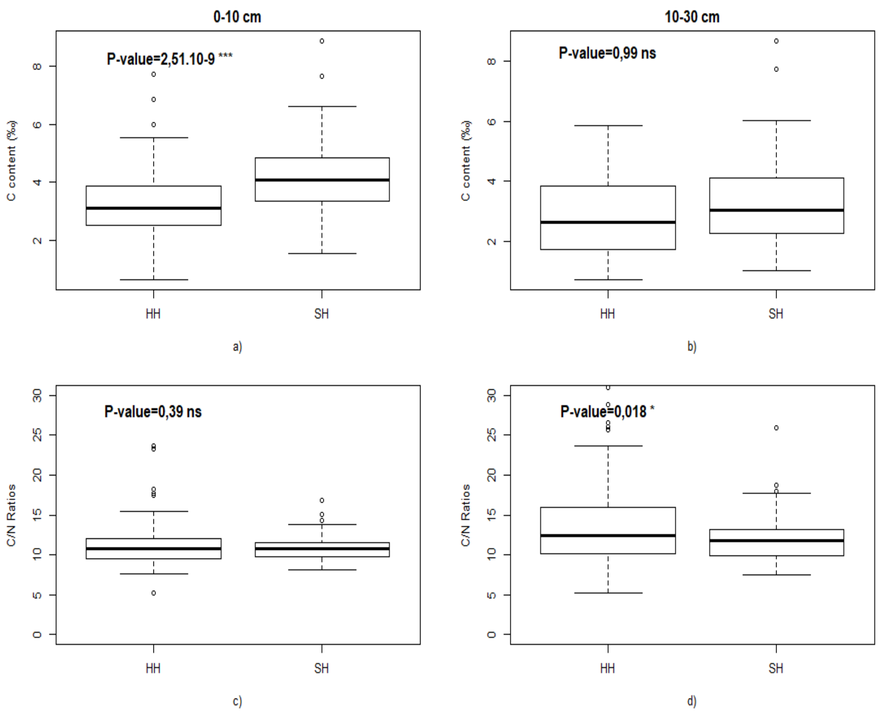
- Total carbon stocks (up to 18.5 t.ha^{-1}) were lower than those in the area (20.6 t.ha^{-1}) reported in Woomer et al. (2004), but higher than as observed for other deserts and bush (15.4 t.ha^{-1}; Henry et al., 2009).

  Indeed, the difference observed may be related to those in the depth explored (30 vs 40-cm deep)
- Variation in soil C stocks seems to be linked to a North-South gradient in environmental factors as rainfall fluctuations influence the density of leafing trees (Hiernaux et al., 1994) and the productivity of Sahelian pastures (Penning de vries and Djitèye, 1982). Better soil chemical properties already observed under trees in the Northern Sylvopastoral area (Apko et al. 2005) and microclimate under tree cover may induce greater soil microbiological (Diallo et al., 2017).

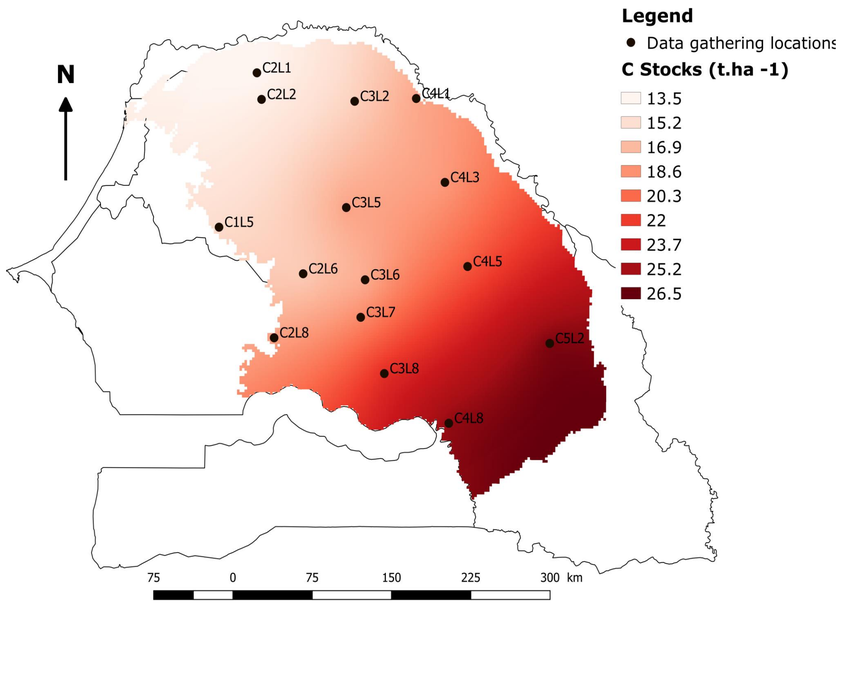
Correlations between stocks and environmental factors

	C Stock (t.ha -1)			Stock C –to – Stock N (t.ha-1)		
Factors	HH	SH	Totals	HH	SH	Totals
Rainfall (mm.an^{-1})	**0.39**	0.12	**0.41**	**0.50**	0.77	0.69
Arbory Coverage rate (%)	**0.32**	0.15	**0.42**	0.26	0.28	0.24
Leaf biomass of trees (kg dry matter per ha)	**0.31**	0.12	**0.33**	**0.41**	0.78	0.65

0.0 : R^2 significant at 5%



Difference between under (SH) and outside (HH) the crown in the content of soil C and C/N ratios respectively at 0-10 cm (a and c) and 10-30 cm (b and d) deep



Spatial variation of the C stock across the sylvopastoral zone of Senegal at 0-30 cm deep

Our study highlighted

- **the positive impact of trees on the C and N contents and stocks in soils of the sylvopastoral area of Senegal,**
- **a North-South gradient in soil C stocks according to rainfall and tree cover.**

More research needed on soil C and N contents and stocks in the silvo-pastoral area:

- Document the influence of microrelief and season.
- Estimate the respective and cumulated contributions of cultivated plants and cattle

Akpo, L.E., Goudiaby, V.A., Grouzis, M., Le Houerou, H.N., 2005. Tree shade effects on soils and environmental factors in a savanna of Senegal. West Afr. J. Appl. Ecol. 7, 12.;Diallo, M.D., Goalbaye, T., Mahamat-Saleh, M., Sarr, P.S., Masse, D., Wood, S.A., Diop, L., Dick, R.P., Diop, A., Guisse, A., 2017. Effects of major woody species of the Senegalese Great Green Wall on N mineralization and microbial biomass in soils= Effets des principales essences de la grande muraille verte sénégalaise sur les taux d'azote minéral du sol et la biomasse microbienne. Bois Forets Trop. 43–54; Hiernaux, P.H.Y., Cissé, M.I., Diarra, L., De Leeuw, P.N., 1994. Fluctuations saisonnières de la feuillaison des arbres et des buissons sahéliens. Conséquences pour la quantification des ressources fourragères. Rev. D'Elevage Médecine Vét. Pays Trop. 47, 117–125.; Penning de Vries, F.W.T., Djitèye, M.A., 1982. La productivité des pâturages Sahéliens: une étude des sols, des végétations et de l'exploitation de cette ressource naturelle 24.; Woomer, P.., Touré, A., Sall, M., 2004. Carbon stocks in Senegal's Sahel Transition Zone. J. Arid Environ. 59, 499–510.; Henry, M., Valentini, R., Bernoux, M., 2009. Soil carbon stocks in ecoregions of Africa. Biogeosciences Discuss. 797–823.